

# Contribution of Abdominal Aortic Aneurysmectomy to Prolongation of Life

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THE logical foundation of elective treatment of abdominal aortic aneurysms by resection and grafting is the assumption that aneurysmectomy restores to the patient the life expectancy he would have had without the risk of a potentially lethal lesion. If the concept of randomized case study is left out of consideration as, for practical reasons, inapplicable, there are two statistical methods to test the validity of this assumption: 1) A comparison of the postoperative survival experience in a group of surgically treated cases with the survival experience in a statistically similar, simultaneously observed nonsurgically treated group of cases of abdominal aortic aneurysm. 2) A comparison of the survival experience of a group of surgically treated patients with the survival experience of an appropriately selected sample of the general population for the determination of the degree to which the survival experience of the former approximates that of the latter; this method, obviously, will yield information of limited value. In the relevant published reports dealing with results of surgical treatment of abdominal aortic aneurysms<sup>1, 2, 4, 5, 7, 9</sup> the first-named method has been widely used but with a modification that seriously affects the significance of recorded findings—the estimate of the difference between the surgical and non-

surgical survivor experiences has been based, almost without exception, on comparison with a single series of nonsurgical cases<sup>3</sup> that antedated the surgical observations by 15 to 25 years. Moreover, the statistical treatment of the surgical data in some of these reports is incomplete or imprecise. It seemed to us, therefore, that analysis of our experience with survival rates of a group of surgical and another group of nonsurgical cases of abdominal aortic aneurysms, observed nearly contemporaneously and evaluated by direct comparison, might contribute to a better definition of the value of abdominal aortic aneurysmectomy from the point of view of prolongation of life.

## Case Material

The clinical material of this study was drawn from the cases of abdominal aortic aneurysms seen in the Henry Ford Hos-

TABLE 1. *Clinical Material*

Period of Observation	Surgical		Nonsurgical	
	No. Cases	% of Total	No. Cases	% of Total
1944-1951	0	0.0	23	10.3
1952-1955	25	5.2	29	13.0
1956-1957	39	8.1	19	8.5
1958-1959	78	16.3	43	19.3
1960-1961	91	19.0	44	19.8
1962-1963	102	21.2	48	21.5
1964-1965	145	30.2	17	7.6
Totals	480	100.0	223	100.0

Follow up complete in all cases as of 12-31-65.

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TABLE 2. *Clinical Material: Clinical Types of Aneurysm*

	Asymptomatic		Expanding		Ruptured		Total	
	No. Cases	%	No. Cases	%	No. Cases	%	No. Cases	%
Surgical	309	64.4	92	19.2	79	16.4	480	100.0
Nonsurgical	198	77.1	14	5.4	11	17.5	223	100.0

*Surgical:*  $\leq 6$  cm., 130 cases (27.3%);  $> 6$  cm., 350 cases (72.7%).  
*Nonsurgical:*  $\leq 6$  cm., 82 cases (36.7%);  $> 6$  cm., 141 cases (63.3%).

pital between January 1, 1944 and December 31, 1965 (Tables 1, 2). Nonsurgical cases were observed through the whole range of these years; the period of observation for surgical cases commenced in 1952, when the first abdominal aortic aneurysmectomy was performed in our hospital. No question arises, of course, about the criteria of selection of the surgical cases for consideration in the study; they were all included. In the nonsurgical cases, however, selection is a difficult and critical problem. Problems of case selection arise regarding criteria of diagnosis and reasons for the lack of surgical treatment. Diagnosis of an abdominal aortic aneurysm cannot be regarded as unconditionally valid when it was made by physical signs alone, since judgment based on physical findings often give rise to errors both in the sense of mistaking a nonaneurysmal lesion for an aneurysm and in the sense of failing to detect the presence of an aneurysm. With respect to the determination of size in particular, findings on physical examination

are highly inaccurate. For these reasons, with very few exceptions, diagnosis of abdominal aortic aneurysm was not accepted and the patient was not included in this study unless the diagnosis had been confirmed by plain x-rays, angiography, or palpation at laparotomy, or autopsy. Exceptions consisted of cases in which the aneurysm was classified as medium-sized or large and was palpated by at least two experienced examiners, and when the presence of an intra-abdominal mass of other type had been ruled out with reasonable certainty by objective means (Table 3). With regard to the reasons for the lack of surgical treatment, their consideration is of paramount importance in the choice of the case material. At first glance one may think that cases judged unsuited for resection should not be part of a study aimed at comparing their survival experience with that of a surgically managed group, since factors that prohibited their surgical treatment can be assumed to have affected adversely their life expectancy. For reasons

TABLE 3. *Method of Determining Size of Nonsurgical Aneurysms*

Size	Method										Totals	
	Phy. Exam.		Soft Tissue		Angiogram		Laparotomy		Autopsy			
			X-ray						Autopsy			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Small	0	0.0	21	9.4	38	17.0	8	3.6	15	6.7	82	36.7
Medium-sized	16	7.2	15	6.7	26	11.7	9	4.1	33	14.8	99	44.5
Large	10	4.5	4	1.8	7	3.1	13	5.8	8	3.6	42	18.8
Totals	26	11.7	40	17.9	71	31.8	30	13.5	56	25.1	223	100.0

Definitions: Small: 6 cm. or less; medium- 7-10 cm.; large: over 10 cm.  
In some tabulations, medium-sized and large aneurysms are grouped together and designated as large.

TABLE 4. Comparison of 480 Surgical and 223 Nonsurgical Cases as to Age, Cardiac Status, Blood Pressure and Renal Function

Age (Yr.)	Surgical		Nonsurgical		Cardiac Status	Surgical		Nonsurgical	
	No.	%	No.	%		No.	%	No.	%
45-50	12	2.5	6	2.7	Normal	336	74.5	137	71.0
51-60	150	31.3	48	21.5	Class I	65	14.4	27	14.0
61-70	243	50.6	92	41.3	Class II	44	9.8	20	10.4
71-80	71	14.8	61	27.4	Class III	4	0.9	7	3.6
80+	4	0.8	16	7.1	Class IV	2	0.4	2	1.0
Totals	480	100.0	223	100.0		451	100.0	193	100.0
					I.I.	29 Cases		30 Cases	

Syst. B.P. (mm. Hg)	Surgical		Nonsurgical		Renal Function	Surgical		Nonsurgical	
	No.	%	No.	%		No.	%	No.	%
<150	229	50.9	82	38.3	BUN (mg. %)				
150-200	198	44.0	82	38.3	<30	430	92.5	173	88.3
200-250	22	4.9	48	22.4	30-60	35	7.5	16	8.2
					>60	0	0	7	3.5
>250	1	0.2	2	1.0	Totals	465	100.0	196	100.0
Totals	450	100.0	214	100.0	I.I.	15 Cases		27 Cases	
I.I.	30 Cases		9 Cases		Bl. Creatinine (mg. %)				
					<2	406	96.4	135	94.4
					>2	15	3.6	8	5.6
					Totals	421	100.0	143	100.0
					I.I.	59 Cases		80 Cases	

(1) I.I., Information incomplete.  
(2) Cardiac Class I: myocardial infarction more than 3 mo. earlier, no angina; Class II: myocardial infarction more than 3 mo. earlier, angina; Class III: myocardial infarction less than 3 mo. earlier, no angina; Class IV: myocardial infarction less than 3 mo. earlier, angina.

that will be presented in detail, the decision was made that these cases were to be included in the study unless the operative contraindication was the presence of an inoperable malignant disease.

Owing in part to the method of selection of the nonsurgical cases, the surgical and nonsurgical groups had certain differences as to age distribution, cardiac status, presence and degree of hypertension, and pulmonary and renal function (Table 4). Since these dissimilarities were limited to numerically rather small segments of the clinical material, their significance in the calculation of comparative survival rates was anticipated to be small. Nevertheless, in order to reduce any possible bias that

might have resulted, special subdivisions were compiled in which, by design, the important differences were eliminated; these subdivisions were designated as "standardized groups." For exclusion of patients from a respective standardized group the criteria were as follows: age over 70 years, systolic blood pressure over 150 mm. Hg, cardiac status of Class II, III and IV blood creatinine level over 2 mg.% and significant pulmonary disease (usually emphysema).

As far as the longevity status of the patients is concerned, the follow-up information on the clinical material was complete in every instance as of the closing date of the study (December 31, 1965). There

were, however, two nonsurgical cases in which the exact cause of death remained unknown.

## Method of Study and Results

### Study of Cumulative Survival Rates

The first fundamental problem this study essayed to probe was the determination of the comparative cumulative survival rates of the surgical and nonsurgical patients. The analysis was carried out in two ways: 1) by direct comparison of the groups and 2) by comparison of each with the calculated survival rates of a corresponding sample of the general population.

**Methods of Computation.** The method of calculating the cumulative survival rates of clinical cases of varying length of follow up is made somewhat complex by the differences in the survival experiences of the various follow up groups according to the length of time elapsed between the date of their entry into the follow up study and the date of termination of the study. The method used in this survey can be best described with the help of a hypothetical example and some simple sketches.\*

Figure 1 illustrates the mathematical framework for the computation of cumulative survival rates in a hypothetical group of 100 cases of aneurysmectomy performed during a period of 4 years at the rate of 25 operations a year between 1962 and 1965 inclusive. Vertical bars contain the number of patients who were operated upon in years such that they can have been followed for the indicated number of years. Each bar, except the first one, represents not a single calendar year but a mixture of years. For example, the 3-year follow up bar has patients from 1962 and 1963, that is, all those patients who were capable of being followed for at least 3 years. Rec-

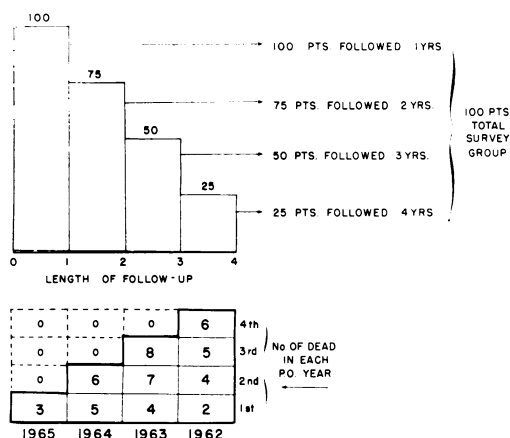


FIG. 1. Graphic schema for method of computation of cumulative yearly survival rates. (For details of method sketched in this figure and Fig. 2, 3, see text.)

tangles under the vertical bars contain the numbers of the patients who died in any given follow up year from the first to the fourth.

For the calculation of the *first* follow up year (Fig. 2a), the number of those deaths is found that occurred during every first postoperative year of observation for all groups; these are the numbers in the lightly stippled squares. The total of these deaths will give the figure whose ratio to the total number of patients followed from zero to one year yields the survival rate for the first year of follow up. The cumulative survival rate of the second follow up year (Fig. 2b) will be based on the sum of all the deaths that occurred during the first and second years of follow up in cases that were exposed to the risk of death for at least two years. (The deaths observed in the cases with only one year of follow up may not, therefore, be included.) Rates for the third and fourth follow up years (Figs. 3a and 3b) will be computed on the same principles, that is, the total number of deaths that took place during all the years in which the given follow up group was exposed to the risk of death is summed and the ratio of this total to the number of cases in the respective follow up group is

\* In working out this method as well as in assisting with all statistical calculations, George H. C. Stobie, M.D., Director, Computer Center, Henry Ford Hospital, was of inestimable help.

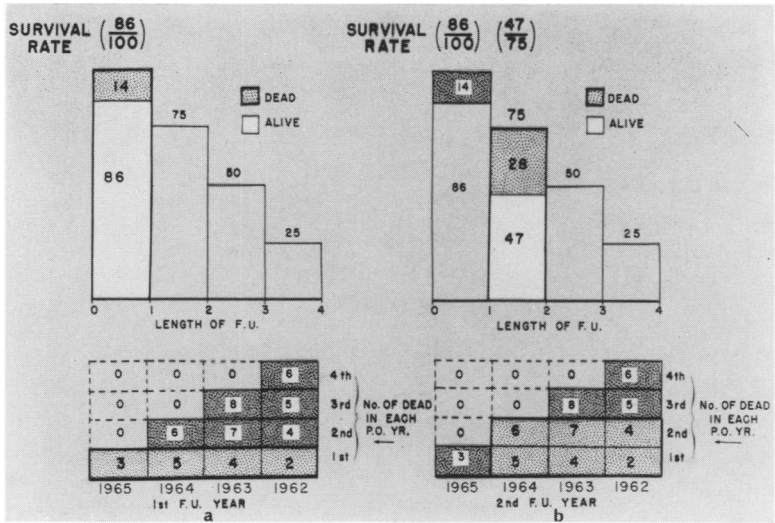


FIG. 2. Steps in computing cumulative yearly survival rates for the first and second years of follow up in a hypothetical group of cases followed for 4 years.

calculated. The survival rates for each follow up year can then be expressed as percentages of survivors, tabulated and plotted.

**Comparison of Survival Curves.** The comparison of the clinical groups with each other and with the respective population samples was carried out by constructing survival curves. After the percentages of survivors had been computed in the manner just described, the percentages were plotted against lengths of follow up at intervals of one year. The sex and age composition of each follow up group was de-

termined, and a sample of population was compiled with the same age and sex distribution. The probability of survival of this artificial sample for the respective follow up interval was then read off standard United States Life Tables<sup>8</sup> and the calculated number of survivors was tabulated and plotted in the same manner as that used for the observed survival figures in the surgical and nonsurgical cases. (The clinical and census data were collected and sorted on punch cards and then transferred to magnetic tape; all computations were made on electronic equipment.)

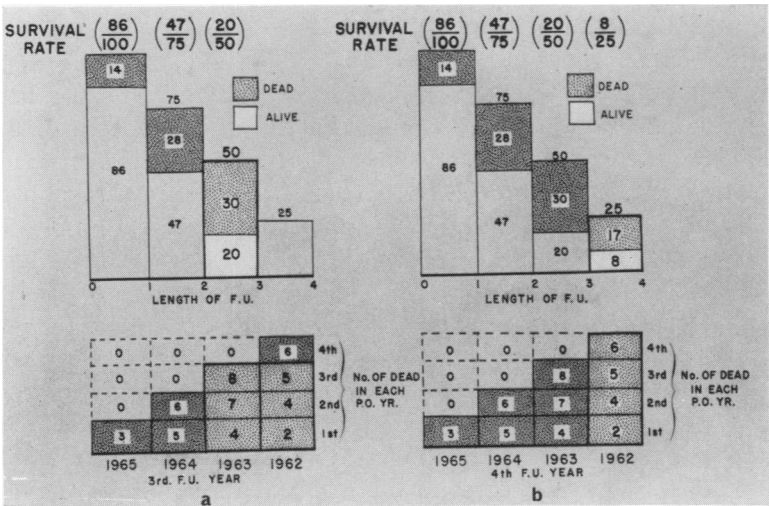


FIG. 3. Steps in computing cumulative yearly survival rates for the third and fourth follow up years in a hypothetical group of cases followed for 4 years.

TABLE 5. Cumulative 13-Year Survival Experience of 434 Surgical and 223 Nonsurgical Patients

Surgical				Nonsurgical			
Year of Follow Up	Patients Followed for Indicated Year	Survivors for Indicated Year	Survival Rate for Indicated Year (%)	Year of Follow Up	Patients Followed for Indicated Year	Survivors for Indicated Year	Survival Rate for Indicated Year (%)
1	434	336	77.5	1	223	121	54.3
2	362	253	69.9	2	218	90	41.3
3	298	189	63.4	3	212	68	32.1
4	239	132	55.2	4	192	46	24.0
5	202	99	49.0	5	163	28	17.2
6	154	63	40.9	6	140	19	13.6
7	122	39	32.0	7	119	14	11.8
8	82	25	30.5	8	97	6	6.1
9	52	15	28.8	9	75	1	1.3
10	36	10	27.8	10	65	1	1.5
11	21	5	23.8	11	55	0	0
12	10	2	20.0	12	47	0	0
13	2	0	0	13	36	0	0

Survival curves were constructed both for unstandardized surgical and nonsurgical and for standardized surgical and non-surgical groups. The survival curve of the unstandardized group of surgically treated cases (Table 5, Fig. 4) showed a slope that fell precipitously during the first year of follow up owing to the occurrence in this time period of the greatest single cause of loss of life, i.e., the operative deaths. Thereafter the curve followed a linear downward

trend, falling off again steeply for the 10th to 13th year of observation, when it reached the zero line. The minor irregularities in the shape of the curve were due to the inevitable unevenness of statistical parameters (age, cardiac status, etc.) in the yearly patient groups. The survival curve of the unstandardized group of nonsurgical cases (Fig. 4) showed an early steep fall, after which it sloped at an even rate to the zero line at 11 years; the early sharp decline

TABLE 6. Cumulative 13-Year Survival Experience in 248 Surgical and 105 Nonsurgical Aneurysms (Standardized for Age, Cardiac Status, Blood Pressure and Renal Function)

Surgical				Nonsurgical			
Year of Follow Up	Patients Followed for Indicated Year	Survivors for Indicated Year	Survival Rate for Indicated Year (%)	Year of Follow Up	Patients Followed for Indicated Year	Survivors for Indicated Year	Survival Rate for Indicated Year (%)
1	248	209	84.3	1	105	62	59.1
2	203	156	76.8	2	101	46	45.5
3	157	109	69.4	3	99	35	35.4
4	118	71	60.2	4	92	25	27.2
5	102	54	52.9	5	73	14	19.2
6	84	37	44.0	6	62	10	16.1
7	67	24	35.8	7	54	9	16.7
8	42	14	33.3	8	41	3	7.4
9	27	7	25.9	9	29	1	3.4
10	21	4	19.0	10	26	1	3.8
11	12	2	16.7	11	22	0	0
12	7	1	14.3	12	18	0	0
13	1	0	0	13	16	0	0

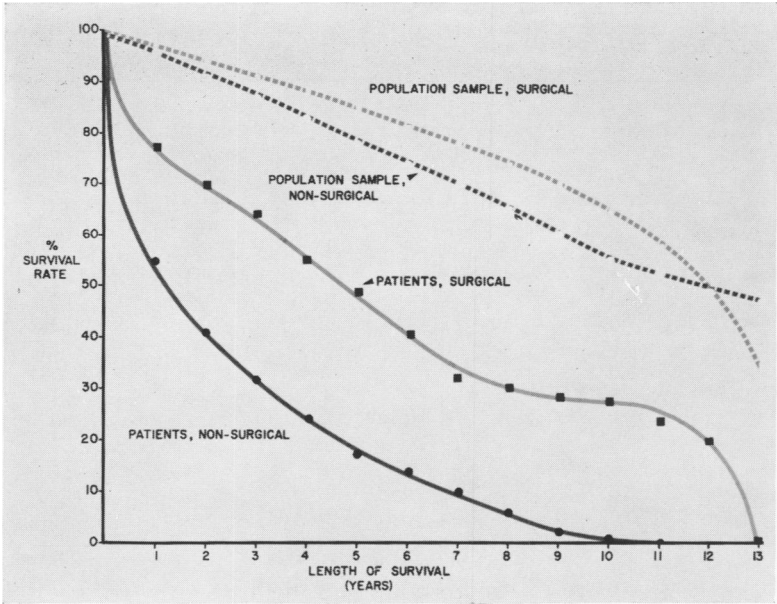


FIG. 4. Observed cumulative 13-year-survival experience of 434 surgically and 223 nonsurgically treated cases of abdominal aortic aneurysm and calculated survival experience of general-population samples compiled for corresponding sex and age distribution. (Source of data: Table 5.)

was, in part, the result of the inclusion in the first-year group of the ruptured aneurysms without clinical history of an aneurysm that died at the time of, or shortly after, admission, without surgical treatment. Even on visual inspection the superiority of the survival experience of the surgical cases is evident. In comparison with the general population sample, the

survival experience of both the surgical and nonsurgical cases disclosed a considerable deficit. The deficit was of the order of 80 per cent for the nonsurgical cases and of the order of 25 per cent for the surgical cases.

Because of the dissimilarities between the two clinical groups, the true differences between their survival rates are best dem-

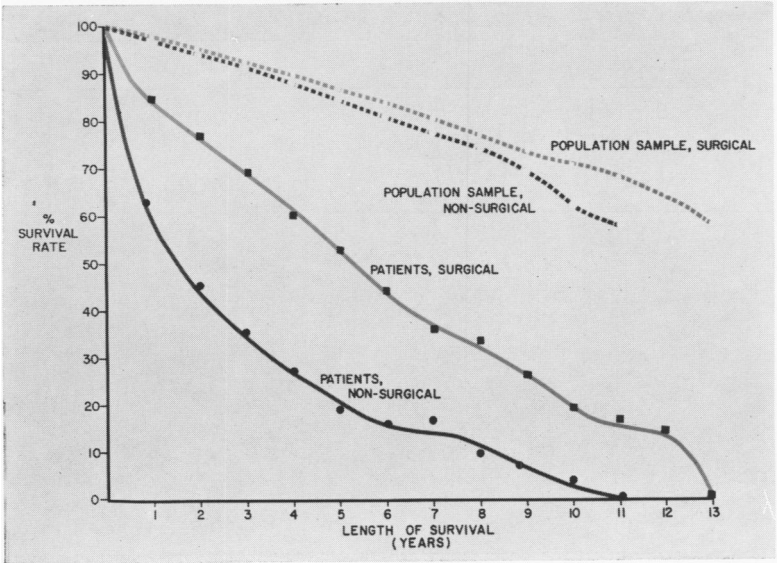


FIG. 5. Observed cumulative 13-year-survival experience of 244 surgically and 105 nonsurgically treated cases of abdominal aortic aneurysm standardized for age, cardiac status, blood pressure and renal function, and calculated survival experience of general-population samples compiled for corresponding sex and age distribution. (Source of data: Table 6.)

TABLE 7a. Cumulative 13-Year Survival Experience by Size—105 Nonsurgical Aneurysms  
(Standardized for Age, Cardiac Status and Blood Pressure)

Nonsurgical							
Small (<6 cm.)				Large* (>6 cm.)			
Year of Follow Up	Patients Followed for Indicated Year	Survivors for Indicated Year	Survival Rate for Indicated Year (%)	Year of Follow Up	Patients Followed for Indicated Year	Survivors for Indicated Year	Survival Rate for Indicated Year (%)
1	44	33	75.0	1	61	29	47.5
2	43	31	72.1	2	58	15	25.9
3	41	28	68.3	3	58	7	12.1
4	35	20	57.1	4	57	5	8.8
5	23	11	47.8	5	50	3	6.0
6	20	9	45.0	6	42	1	2.4
7	19	8	42.1	7	35	1	2.9
8	13	3	23.1	8	28	0	0
9	10	1	10.0	9	19	0	0
10	9	1	11.1	10	17	0	0
11	7	0	0	11	15	0	0
12	4	0	0	12	14	0	0
13	4	0	0	13	12	0	0

\* Includes both medium-sized and large aneurysms.

onstrated by comparing the survival curves of the so-called standardized groups (Table 6, Fig. 5), since these groups were similar in all the more important prognostic aspects. These survival curves disclosed a narrowing of the difference in their slopes but their general behavior remained unchanged. By integrating the area enclosed under each curve one can find the value of the respective overall survival experience; this proved to be 2.1 times greater for the surgical cases. If the statistical comparability of the two groups is granted, removal of the aneurysm may be said to have doubled the life expectancy of the surgical group.

Two remarks concerning the survival curves so far discussed seem pertinent. First, it should be noted that the survival curve of the surgical cases would not parallel the curve of the general-population sample even if the single most important factor causing its slope, operative mortality, were reduced to zero. Obviously, patients with aneurysmectomy cannot have the same survival expectancy as the general

population since they suffer of a specific disease: systemic arteriosclerosis, of which the aneurysm is merely an isolated manifestation. Secondly, the shape of the survival curves beyond the tenth follow up year, because of the smallness of the number of patients in the subsequent follow up groups, must be regarded as approximate.

In view of the increased importance that the size of aneurysms is gaining in decisions of operability—a problem to be considered in more detail presently—survival curves were made also for groups of cases in which the more important parameters affecting survival were reduced to the single one of aneurysm size.\* A comparison of small nonsurgical with large nonsurgical aneurysms showed a considerably better survival experience for the former (Table 7a, Fig. 6). The survival experience of small surgically treated aneurysms, on the other hand, was superior by a significant margin to that of small aneurysms that were not treated surgically (Tables 7a, b; Fig. 7).

\* The transverse diameter at the widest part was taken as the measure of size.

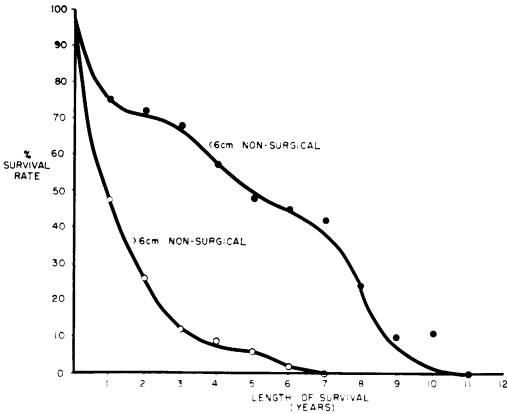


FIG. 6. Observed cumulative 13-year-survival experience of 44 cases of small (<6 cm.) and 61 cases of large (>6 cm.) nonsurgical abdominal aortic aneurysm standardized for age, cardiac status, blood pressure and renal function. (Source of data: Table 7a.)

Factors Affecting Loss of Life

The second goal of the study was an analysis of the clinical factors that determine the loss of life both in the surgical and in the nonsurgical cases. Loss of life in the surgical cases is defined as being made up of two sets of events: operative and postoperative (or late surgical) mor-

tality; in nonsurgical cases it is equivalent to the observed death rate during the study period.

**Operative Mortality.** Operative mortality for all three types of aneurysms— asymptomatic, expanding, and ruptured— showed a steady decline throughout the observation period (Table 8, Fig. 8). The mortality for asymptomatic and expanding aneurysms for the entire period of observation was 14.7 per cent, and for the last 2 years 6.3 per cent. By far the most common cause of operative death was coronary heart disease (47.5%) (Table 9, Fig. 9).

The more important factors affecting operative mortality—age, cardiac status, blood pressure, and renal and pulmonary function—were analyzed by the method of standardizing the patient groups as previously mentioned (Table 10). In studying the effect of age on operative mortality, for instance, patients with the entire range of variation of age remained in the group but patients with certain predetermined cardiac, hypertensive, renal and pulmonary findings were excluded. For the exclusion

TABLE 7b. Cumulative 13-Year Survival Experience by Size—248 Surgical Aneurysms (Standardized for Age, Cardiac Status, Blood Pressure and Renal Function)

Surgical							
Small (≤6 cm.)				Large* (>6 cm.)			
Year of Follow Up	Patients Followed for Indicated Year	Survivors for Indicated Year	Survival Rate for Indicated Year (%)	Year of Follow Up	Patients Followed for Indicated Year	Survivors for Indicated Year	Survival Rate for Indicated Year (%)
1	74	69	93.2	1	174	140	80.5
2	63	55	87.3	2	140	101	72.1
3	52	43	82.7	3	105	66	62.9
4	37	27	73.0	4	81	44	54.3
5	30	20	66.7	5	72	34	47.2
6	23	14	60.9	6	61	23	37.7
7	18	10	55.6	7	49	14	28.6
8	11	7	63.6	8	31	7	22.6
9	5	3	60.0	9	22	4	18.2
10	4	1	25.0	10	17	3	17.6
11	1	0	0	11	11	2	18.2
12	0	0	0	12	7	1	14.3
13	0	0	0	13	1	0	0

\* Includes both medium-sized and large aneurysms.

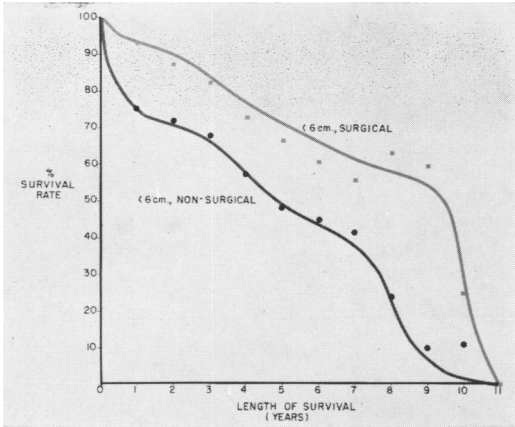


FIG. 7. Observed cumulative 13-year-survival experience of 44 cases of small (<6 cm.) abdominal aortic aneurysm treated nonsurgically and 74 cases of small abdominal aortic aneurysm treated surgically; both groups standardized for age, cardiac status, blood pressure and renal function. (Source of data: Table 7a and 7b.)

of patients from any given standardized group the criteria were the same as previously listed.

Coronary artery disease, hypertension and aneurysm size had a strong positive correlation with increased mortality. The effect of age, on the other hand, was much less marked undoubtedly for the reason that chronological age is often not equivalent with physiological age. An interesting correlation was found also in a sample analyzed for the elusive factor of “experience,” in which all variables were held optimal and the mortality was tabulated in chrono-

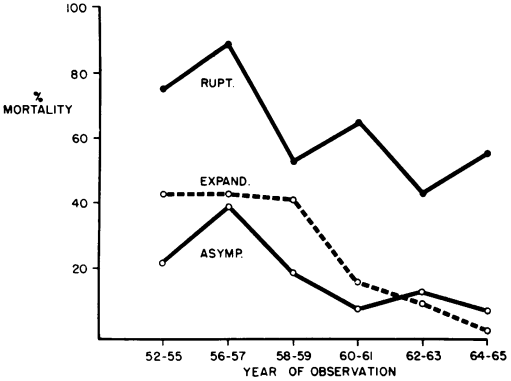


FIG. 8. Operative mortality of 309 asymptomatic, 92 expanding and 79 ruptured abdominal aortic aneurysms according to year of operation. Operative mortality is defined as death from any cause traceable to the surgical intervention, regardless of time interval.

logical order. Here with the passing years the operative mortality showed a steady and marked decline, presumably owing to the complex objective and subjective change in surgical skill and technics, the accumulation of which through time constitutes “experience.”

**Postoperative Mortality.** Arteriosclerotic heart disease remained a leading cause of death in the postoperative period (Table 11, Fig. 9), followed by cerebral arteriosclerosis, graft failure, malignancy and renal arteriosclerosis. The term “graft failure” included all deaths attributable to malfunction of the aortic implant, whether due to infection, hemorrhage or disruption.

TABLE 8. Operative Mortality by Period of Observation

Year of Observation	Type of Aneurysm					
	Asymptomatic		Expanding		Ruptured	
	No. Cases	% Mort.	No. Cases	% Mort.	No. Cases	% Mort.
1952-1955	3/14	21.4	3/7	42.9	3/4	75.0
1956-1957	9/23	39.1	3/7	42.9	8/9	88.8
1958-1959	8/44	18.2	7/17	41.2	9/17	52.9
1960-1961	3/49	6.1	4/25	16.0	10/17	64.7
1962-1963	9/68	13.2	2/20	10.0	6/14	42.9
1964-1965	8/111	7.2	0/16	0.0	10/18	55.6

(1) Operative mortality: death from any cause, however remote, traceable to the surgical procedure.  
(2) Mortality rate for entire group (except ruptured): 14.7%; for 1964-65, 6.3%.

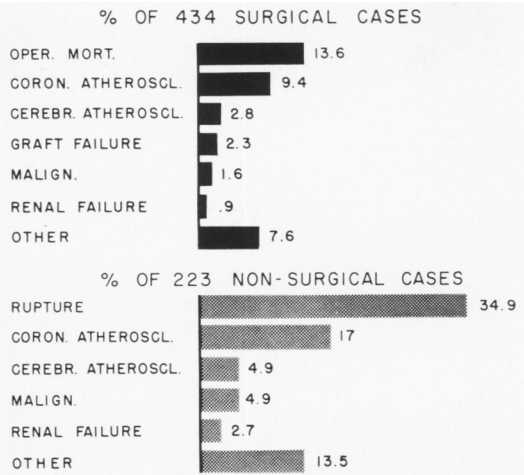


FIG. 9. Causes of loss of life in entire clinical material. 'Loss of life' comprises the deaths in non-surgical cases and both the operative and post-operative deaths in surgical cases. Base figure for calculating surgical loss of life includes survivors of operations for rupture.

The importance of arteriosclerotic involvement of the heart was again demonstrated by a study of a group of patients standardized in the manner already described (Table 12). The late mortality of the pa-

TABLE 9. Causes of Operative Death in 401 Cases of Asymptomatic and Expanding Aneurysms

Cause of Death	No. Deaths	% of Total Deaths
Cor. art. disease	28	47.5
Renal failure	10	16.9
Hemorrhage	10	16.9
Pulmonary	7	11.9
Peritonitis	2	3.4
Other	2	3.4
Totals	59	100.0

tients in cardiac Class III and IV was significantly higher than of those with normal heart or in cardiac Class I and II. Hypertension had a closely similar effect on late mortality.

**Mortality of Nonsurgical Cases.** By far the commonest cause of death in this group was rupture (Table 11, Fig. 9), 34.9 per cent of the patients having died of it. While the consistently better long-term survival of the surgically treated patients is a suggestive evidence of the value of aneurysmectomy, the direct proof that this superiority is the result of the removal of the

TABLE 10. Effect of Age, Cardiac Status, Size of Aneurysm, Hypertension and Experience on Operative Mortality

Age (Yr.)	Oper. Mortality		Cardiac Status	Oper. Mortality	
	No.	%		No.	%
40-50	0/2	0.0	Normal	10/113	8.8
51-60	7/54	13.0	Class I	5/26	19.2
61-70	8/83	9.6	Class II	3/14	21.4
71-80	3/18	16.7	Class III	1/2	50.0
80+	0/1	0.0	Class IV	0/0	0.0
Total	18/158		Total	19/155	

Size Aneur.	Oper. Mort.		Syst. B.P. (mm. Hg)	Oper. Mort.		"Experience" Obser. Period	Oper. Mort.	
	No.	%		No.	%		No.	%
Small (<6 cm.)	1/37	2.7	<150	15/139	10.8	1052-5	2/3	66.7
Medium (6-10 cm.)	6/51	11.8	150-200	22/131	16.8	1956-7	9/20	45.0
Large (>10 cm.)	5/22	22.7	200-250	4/14	28.6	1958-9	13/48	27.1
			>250	0/0	0.0	1960-1	4/59	6.8
Total	12/110		Total	41/284		1962-3	7/70	10.0
						1964-5	3/86	3.5
						Total	38/285	

Groups standardized for age, cardiac status, hypertension and renal and pulmonary function, as the case may be.

aneurysm ultimately rests in the very important role of aneurysm rupture as cause of death in the untreated group. Coronary atherosclerosis was the second leading cause of loss of life, having been responsible for about half as many deaths as was rupture.

**Incidence, Distribution and Lethality of Aneurysms According to Size.** As stated earlier, since the clinical diagnosis of a small aneurysm is unreliable, only those lesions in this category of size were included in the tabulation that had been diagnosed by objective means (Table 3). Aneurysms of small size (less than 6 cm. in diameter) have been seen with increasing frequency (Table 13). It already has been pointed out that in the nonsurgical group the survival rates of these lesions were better than those of large ones (Table 7a, Fig. 6), and that the survival experience of small untreated aneurysms was sig-

TABLE 11. *Causes of Loss of Life (Nonsurgical and Total Surgical Mortality)*  
434 Surgical Cases

Cause of loss of life	No. Cases	%
Operative mortality*	59	14.7
Postoperative mortality	107	24.6
Coronary atherosclerosis	41	9.4
Cerebral atherosclerosis	12	2.8
Graft failure	10	2.3
Malignancy	7	1.6
Renal failure	4	0.9
Other	33	7.6
Total	166	39.3

*223 Nonsurgical Cases*

Cause of loss of life	No. Cases	%
Rupture	78	34.9
Coronary atherosclerosis	38	17.0
Cerebral atherosclerosis	11	4.9
Malignancy	11	4.9
Renal failure	6	2.7
Other	30	13.5
Total	174	77.9

\* Ruptured aneurysms not included.

TABLE 12. *Factors Affecting Postoperative (Late) Mortality*

*Effect of Hypertension*

Blood Pressure*	Mortality	
	No.	%
<150	36/160	22.5
150-200	36/134	26.9
200-250	6/13	46.2
>250	0/0	0.0
Totals	78/307	25.4

*Effect of Cardiac Class*

Cardiac Class**	Mortality	
	No.	%
Normal	22/123	17.9
Class I	7/24	29.2
Class II	7/13	53.8
Class III	1/2	50.0
Class IV	0/0	0.0
Totals	37/162	22.8

\* Group standardized for age, cardiac status and renal function.

\*\* Group standardized for age, blood pressure and renal function.

nificantly worse than that of treated small aneurysms (Tables 7a, b; Fig. 7). The incidence of rupture and the overall mortality of small untreated aneurysms, as one would expect from the foregoing, were lower than those of larger aneurysms (Table 14).

## Discussion

**Comparability of Surgical and Nonsurgical Cases.** It is perhaps superfluous to state that a study that would fulfill the strictest requirements of statistical analysis in the comparative evaluation of the results of the surgical and nonsurgical treatment of abdominal aortic aneurysms would demand the comparison of groups of cases of each type that were randomly chosen and concurrently observed. Since such a study, for obvious practical reasons, is impossible to carry out, standards of statisti-

TABLE 13. *Distribution of Aneurysm Size According to Period of Observation: Nonsurgical Cases*

Period of Observation	Total Aneur.	Small (<6 cm.) % of Total per Period	Medium-Sized (7-10 cm.) % of Total per Period	Large (>10 cm.) % of Total per Period
1944-1951	23	30.4	52.2	17.4
1952-1956	39	28.2	38.5	33.3
1957-1961	96	31.3	47.9	20.8
1962-1965	65	52.3	40.0	7.7
Totals	223	36.7	44.5	18.8

Size estimated by objective means in 88.3% of the cases.

cal comparison must be defined in less restrictive terms. The indispensable requirement for statistical validity of such a comparison is similarity of the groups with respect to all clinical characteristics (except, of course, the presence of aneurysms) that have an influence on length of survival. For, obviously, such clinical abnormalities may not only lower survival expectancy but also increase the proportion of deaths due to causes other than the rupture of the aneurysm. Application of this standard to the present case material raises complex problems. There were 96 patients who did not receive surgical treatment because it was the judgment of the attending physician that their physical state, owing to age or an associated nonmalignant disease, made such treatment inadvisable (Table 15). One might assume that such a judgment implied that the nonaneurysmal disease was a greater threat to the patient's life than the aneurysm and that, therefore, these cases should be excluded from statistical comparison. A scrutiny of the case histories, however, disclosed that the gravity of the associated diseases varied widely and the criteria of decision regarding their importance in the operative risk and in longevity constantly changed throughout the 13 years of observation. It can be fairly said that, in the vast majority of these instances, by present-day criteria no serious contraindications would have been found. But a separation of these cases by retrospective appraisal would cre-

ate more statistical errors than it would correct. Such an attempt might not only remove from the follow up study cases that ought to remain but would also demand a reclassification of those surgical cases that should be judged inoperable if assessed by the same standards as those that were applied to the nonsurgical cases in the past. The complexity and arbitrariness this procedure would imply are obvious. It was, therefore, elected to leave these cases in the study group. Precautions were taken, however, to test and, if necessary, eliminate bias that might thus have resulted, by constructing subdivisions of cases as explained above, from which the physiologic disparities between surgical and nonsurgical groups were excluded. This method had the important advantage of substituting objective and usually measurable criteria (such as age, electrocardiographic findings, blood pressure, etc.) for the clinician's subjective and often inconsistent judgment. Classification of the cases in standardized subdivisions yielded the interesting observation that the truly significant physiologic dissimilarities between the surgical and nonsurgical cases were confined to relatively small segments of the case material. In good agreement with this finding, the survival experience of the unstandardized and standardized subgroups of nonsurgical cases displayed quite similar, though by no means identical, survival experiences when compared with their respective surgical counterparts. A special word should be said about nonsurgical

TABLE 14. *Comparison of Degree of Lethality of Nonsurgical Aneurysms According to Size*

	<6 cm.		>6 cm.	
	No.	%	No.	%
Incidence of rupture	16/82	19.5	61/141	43.3
Mortality	45/82	54.9	127/141	90.1

Mean length of survival: <6 cm., 34.1 months; >6 cm., 17.0 months.

cases in which malignant disease was encountered in association with an aneurysm. In these instances, if the malignant lesion was either technically or intrinsically incurable, it was excluded from the series; if it was surgically treated with curative intent, it was included.

**Problems of Statistical Treatment of Ruptured Aneurysms.** The statistical handling of ruptured aneurysms poses some questions that require clarification. As regards the cases in which the aneurysm ruptured after a period of medical observation, the procedure of follow up classification is obvious; the length of the known duration of the existence of the aneurysm is entered as the length of follow up. (It is true that the fact that the duration of the existence of the aneurysm before its discovery is not known introduces a serious error into the calculation of the total survival experience of the aneurysm, but the source of this error is beyond control.) It is much more difficult to state what the estimated follow up of a patient should be who, without any previous medical history of aneurysm, dies of the rupture of an aneurysm. Since the point of inception of a disease whose diagnosis depends entirely on the physician's active intervention by examining or otherwise investigating the patient—as is the case with asymptomatic aneurysms—must be counted from the time of this intervention, ruptured aneurysms in this category cannot but be regarded as having had a duration beginning at the time the diagnosis of the rupture was made. By this reasoning we included these cases in our first-year follow up interval, that is, the first interval on our scale of time. It must be remembered that this way of proceeding does not in any way influence the total survival experience of the nonsurgical group but only modifies the shape of the survival curve. In fact, even this effect is slight since these cases represent less than 5 per cent of the nonsurgical group.

TABLE 15. *Reasons for Nonsurgical Management*

Medical contraindications	96
Cardiac	38
Age	8
Other (pulmonary, renal, cerebrovascular, etc.)	50
Lack of surgical method of treatment (before 1952)	31
*Refusal of operation by physician	27
Refusal of operation by patient	21
Small size of lesion	21
Lack of diagnosis before death	18
Death from rupture while waiting for operation	9
	223

\* In these cases the surgeon's opinion was not sought although no apparent contraindication to surgical treatment existed.

Classification of surgically treated ruptured aneurysms raises questions of another type. Should the patients with resection for ruptured aneurysm be included in operative mortality statistics? If they are excluded from operative statistics, should those that survive the operation be also disregarded when late survival experience is considered? We believe that inclusion of ruptured aneurysms in the general operative mortality statistics would detract from the value of the main use for which operative mortality rates are compiled, that is, the numerical expression of the success of the surgeon in accomplishing a goal—the cure of the patient—under conditions over which he has control. Insofar as our experience with ruptured aneurysms is concerned, these cases stand by themselves in regard to almost every factor that ordinarily determines the success of the surgeon's efforts. Our practice is to operate on all these patients as long as there is sign of life present. Nearly half of these cases are in profound hemorrhagic shock and one third are moribund when first seen; indeed in one fifth of the cases the vital signs are difficult to find when the operation starts, and resuscitative efforts are often required. It would seem to be incorrect, therefore, in

the computation of overall operative mortalities, to give the same weight to the operative death rate of these patients as to that of the remainder of the surgical group. Accordingly, in our tabulations general operative mortality does not include the results of ruptured aneurysms. There seems to be no valid objection, on the other hand, to consideration in late survival statistics of patients who recover from an operation for ruptured aneurysm. Regardless of the desperateness of the patient's condition as a candidate for operation, once he has gone through the surgical procedure, from the point of view of late survival he becomes a statistical entity of the same significance as any other postaneurysmectomy patient. Needless to say, this inclusion in the late survival group has no effect on the immediate operative mortality figure from which both the successful and unsuccessful operations for ruptured lesions have been eliminated.

**Comment on Methods of Computing Survival Rates.** If one wishes to compare findings of this study with previously published observations on the survival experience of patients with treated and untreated abdominal aortic aneurysms, it is necessary to examine briefly the methods of computing survival rates used in earlier reports.

As already mentioned, for the correct representation of the survival experience of a group of patients observed at different time periods and dying at different intervals after their entering the time scale of observation, particularly when these survival experiences are expressed as cumulative rates plotted on curves, it is necessary to correlate the actual length of survival of each patient with the length of his potential maximal survival within the time scale of the study; we believe that the method described in some detail in an earlier chapter fulfilled this requirement satisfactorily. This goal cannot, however, be accom-

plished by compiling an array of cases according to the lengths of survival of the patients, or by calculating the number of survivors in given periods of observation, or by forming a life table in which all observations are grouped at the starting point of the scale of time and decreased from year to year by the number of patients who died in each preceding interval.

The requirement of correlating the length of all observed individual survivals with the corresponding life expectancies mentioned above were not followed in all the earlier reports. In the classical study of Estes<sup>3</sup> on the survival experience of non-surgical abdominal aortic aneurysms, the survival rates were computed in accordance with the principles mentioned above. (One may, however, take exception to the method of construction of the survival curve for the normal population, which was based on an average age of the entire clinical material rather than of the individual ages of the patients in the various follow up periods.) The report of Schatz *et al.*<sup>6</sup> on 141 nonsurgical patients utilized the same method. The life expectancy table published by Wright *et al.*, on the other hand, based on observations on 68 nonsurgical patients, contains erroneous figures since it relates the number of survivors in the various follow up periods to the total number of cases observed, making the wrong assumption that all had the same potential life expectancy. MacVaugh and Roberts,<sup>5</sup> tabulated 27 cases of untreated aneurysms in a similar manner. As regards surgically treated lesions, in the massive study of DeBakey *et al.*<sup>2</sup> (1,429 cases), the life table method was used. An error in the calculation of the survival rates is caused by the failure to decrease the number of cases in each observation period by the number of those cases that did not have their operations in an earlier enough follow up interval to be correctly considered for the given observation period. Such an error

increases the survival rates by a margin dependent on the number of patients whose follow up was too short to properly be included in the interval; this error is clearly demonstrated by the large remnant of patients shown to enter the last follow up year, a number far in excess of the number of operations performed during the first year of the surgical experience described. In the report of MacVaugh and Roberts<sup>5</sup> on 92 cases of surgical aneurysms the survival rates were calculated in accordance with the general principles observed in the present study. In other reports of follow up observations on excision of abdominal aortic aneurysms either no attempt was made to construct survival tables or curves,<sup>1, 4</sup> or the methodology is not stated.<sup>7, 8</sup>

It must be stressed that these remarks on the computational methods of other authors are not intended to detract from the accuracy of the recorded observations. It is undeniable, however, that the predictive value of conclusions drawn from such observations depends, in large part, on the appropriateness of the method of computing the survival rates.

**Comparison Between Observed and Previously Reported Survival Experiences.** A valid comparison of clinical data of divergent sources presupposes similarity both in the clinical source materials from which the data were derived and in the methods of their statistical treatment. These similarities are to a great extent lacking between the findings of the present study and those of the earlier reports.

The *surgical* case material of this survey and that of the previous publications dealing with the results of abdominal aortic aneurysmectomy are probably fairly alike owing to the generally similar criteria of operative case selection. Because of the differences in statistical methodology, however, the findings in the present study regarding the survival expectancy and the total survival experience of surgically treated

abdominal aortic aneurysms cannot be put in precise comparative correspondence with those reported by all other authors but one;<sup>5</sup> it is possible only to compare the survival rates of isolated follow up years, but even here the statistical entities being compared are not always identical. Insofar as comparison is permissible, however, formerly reported survival data of surgically treated aneurysms are not importantly different from those encountered in the present survey; that is, the differences are not of the type or magnitude that would preclude the drawings of compatible clinical conclusions, and the conclusions, in a broad sense, agree.

With respect to the survival data of *non-surgical* cases, two reports fulfill the requirement of similarity to the present study in regard to statistical method—those of Estes<sup>3</sup> and of Schatz *et al.*<sup>6</sup>—but both these reports contain dissimilarities from the present study in regard to some important characteristics of the clinical material.\*

Estes' 10-year follow up study of 102 cases of untreated abdominal aortic aneurysms has the outstanding merit of having dealt with cases that constitute an unselected sample since they were observed in a period of time immediately preceding the advent of resective surgical treatment. Although an unspecified number of the diagnoses was made by physical findings alone, this probably was not a source of serious error since in the days of the study abdominal aneurysms were much more likely to be missed than to be overdiagnosed. Estes' follow up success for longevity status was greater than 90 per cent. The survival rates he found, from the third follow up year on, were consistently but not markedly lower than those in the present study; the dis-

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\* A rather lengthy list of publications of the presurgical era of abdominal aortic aneurysm contain voluminous data on survival observations but are so marred by diagnostic and other ambiguities as to be of no use for present-day evaluation.

parities by years of follow up ranged from about 2 to 10 per cent. Concerning the very important problem of the role of rupture as mortality factor, the value of Estes' data is impaired by the lack of precise knowledge of the cause of death in 15 of 64 deceased patients. His stated figure for the incidence of rupture as cause of death is 63.3 per cent but the true figure might be anywhere in the range of 71.9 to 48.4 per cent. But even if one chooses the last-named, lowest possible value, the incidence of rupture among the dead is significantly higher than that in the present series (34.6%). Very likely, the principal cause of this difference is the altered clinical picture of abdominal aortic aneurysms, specifically the prevalence of aneurysms of small size. In the present series, the incidence of small aneurysms among all the nonsurgical aneurysms seen during the past decade has risen from 30 to 52 per cent (Table 10). Obviously, ever since the detailed delineation of the natural history of abdominal aortic aneurysms in the middle and late 1950s, and since the establishment of their effective cure, these lesions have been and are being discovered much earlier in their clinical course than they had been in former years. Undoubtedly the ratio of small to large aneurysms is much higher in our clinical material than it would have been in a study group 15 to 20 years ago. (The precise information in this respect is not, however, available since the earlier reports did not designate aneurysmal size.) Another clinical feature that may have contributed to the difference between the earlier and current rupture and, to a lesser extent, survival rates is the relative incidence of expanding (symptomatic) aneurysmal lesions, the survival expectancy of which, if untreated, is very low (on the average, less than 6 months). In the present group of nonsurgical aneurysms the incidence of this type of lesions was small (6.3%). In Estes' series the aneurysms are

not classified according to symptomatology; from the clinical data given one may speculate that symptomatic lesions may have formed as much as 30 per cent of his case material. To explain the narrowness of the disparity between the survival experiences in Estes' group of patients and those in this study in spite of the much greater incidence of rupture in the former, one must surmise that atherosclerotic cardiac disease, the second most common mortality factor, currently has a greater absolute incidence as cause of death in cases of untreated abdominal aortic aneurysms than it formerly had. (Estes gives no data in this regard.)

The usefulness for comparative evaluation of the 6-year follow up study of Schatz *et al.* on 141 cases of untreated abdominal aortic aneurysms is severely damaged by the circumstances that 80.8 per cent of the patients included in the study were "surgical rejects" and that a very considerable proportion (perhaps 30%) of the aneurysmal lesions were diagnosed by nonobjective means. Not all patients who were advised against surgical treatment were prohibitive risks but it is implied (without the necessary details being stated) that a large majority of them were. One may also suspect that a sizable proportion of the aneurysms listed as small (less than 7.5 cm. in diameter), would have hardly qualified, under objective scrutiny, as true aneurysmal lesions. Since the main thesis of the study is a critique of the justification for the surgical management of abdominal aortic aneurysms by the double criteria of aneurysmal size and associated cardiac disease, the omission of more reliable standards for measuring the size of the lesions and the neglect of grading the cardiac involvement are particularly serious deficiencies. For these reasons, both the survival rates listed and the conclusions drawn from them lose much of their relevance. The yearly survival rates from the first to the

sixth (last) year of follow up were found to be 3.2 to 20.6 per cent higher than those in Estes' report and from 12 to 37 per cent higher than in the present study, for the corresponding years.

**Some Clinical Inferences about Small Aneurysms.** If the correctness of its methods of analysis is granted, this study can be said to have shown that removal of the abdominal aortic aneurysm of a patient doubles the life expectancy he would have should the aneurysm remain untreated. It is, however, important to stress—although it is undoubtedly obvious—that this conclusion is a statistical statement, valid only with reference to a large group of patients, and that it leaves unanswered the question of how much an individual patient may gain when he is subjected to the operation. In judging the possible gain or loss in an individual case, decision must be reached by a subtle balancing of many considerations, some but not all of which can be expressed in statistics. These considerations have been discussed repeatedly and are well known, and only one of them will be touched upon here: that of aneurysmal size, which has lately assumed special importance owing to the steady rise of the incidence of small lesions seen in current clinical practice.

Statistical information relative to the problem of operative indications for small aneurysms is incomplete and somewhat contradictory. The incompleteness is plainly manifest in the coarse method of classification one is obliged to use. Since one is dealing with untreated lesions, most of which were not seen by the surgeon who—at least in the instance of these authors—would have used angiography, details of the dimensions and configuration of the aneurysms were obtained from nonangiographic sources and are often vague. (Even in angiographic images, unless special care is taken to obtain lateral views, the sagittal diameter of the lesion is not seen—a seri-

ous omission, since the aneurysm is a three-dimensional structure.) Frequently it is not possible to determine from the records if the lesion was fusiform or saccular, although, in general, saccular lesions are more prone to rupture. This inability to identify subtle but important morphologic features in available descriptions must be an important reason why one cannot explain the divergences in the behavior of small aneurysms that have been classified as being alike in size. Information is also deficient about the rate of progression in size, particularly as regards both the clinical and the morphological features that may influence this rate, although, on grounds of serial angiographic observations in a fairly sizable number of cases, it can be said that progressive increase in size is always present but its rate varies widely.

Moreover, what firm statistical information is at hand supports both conservatism and aggressiveness in surgical approach. The much better survival expectancy of small aneurysms (which is about 2.5 times that of large aneurysms) favors a conservative attitude. Yet small aneurysms do rupture (within a 10-year observation period in this study 19.5% did), have an appreciably better survival expectancy when they are operated on than when they are untreated, and have a low operative mortality rate (2.7%)—all arguments in favor of an aggressive surgical attitude.

Plainly, a much more comprehensive knowledge of the natural history of small aneurysms would have to be obtained before these ambiguities could be resolved. This knowledge, of course, is yearly becoming more difficult to acquire as increasingly fewer small aneurysms remain untreated.

Nevertheless, even the present stock of information is sufficient for framing some broad but useful guidelines for decisions of operability. Both the facts of the pathologic evolution of aneurysmal lesions and the data of survival statistics suggest that from

the surgeon's point of view the essential difference between a small and a large aneurysm lies in the time relationships of their discovery. The small aneurysm has been detected in an earlier phase of its development and thus it is, all other factors being equal, at a farther point in time from rupture than a larger aneurysm. Patients with a small aneurysm have at their disposal a longer time to wait; but waiting time is not unlimited. Thus, in weighing the urgency of surgical treatment for a small aneurysm the factors that determine the patient's life expectancy apart from the aneurysm have a special importance. After having taken into consideration the total survival experience—mean life expectancy and the mortality rate of ruptured and unruptured small aneurysms, with and without surgical management observed in this study—we find it well justified to say that patients bearing small aneurysms whose life expectancy according to U. S. Life Tables<sup>8</sup> is 10 years or more—which means all patients under 76 years of age—should seriously be considered for resective treatment. The ultimate operative decision would then depend on the careful balancing of the factors that, aside from his age, ultimately determine the patient's chances of living out his predicted life span (and, These factors are usually complex and atherosclerotic heart disease is only one, albeit the most common, of them. Needless to say, when a set of intricate factors must be weighed, decision is not so much a matter of fixed rules as of surgical wisdom.

### Summary and Conclusions

The survival experience of a group of 223 untreated (also designated as nonsurgical) and a group of 480 surgically treated of course, also determine operative risk).\*

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\* It should be added that if a conservative course is chosen, the only trustworthy way of following the further progress of the aneurysmal lesion is periodic angiography.

cases of abdominal aortic aneurysms observed during the past 22 and 13 years, respectively, has been investigated. Survival curves were constructed, and the operative and nonoperative mortality rates were analyzed for the two groups and for subgroups standardized for statistical similarity.

Removal of an abdominal aortic aneurysm was found approximately to double the patient's survival expectancy.

In *surgical* cases, the most important factor influencing survival expectancy was operative mortality, which fell from 14.7 per cent for the entire period of observation to 6.3 per cent calculated for the last two years. The second leading contributor to postoperative loss of life was coronary atherosclerosis which (beside being responsible for 47.5 per cent of the operative mortality) caused 9.4 per cent of the postoperative deaths.

The leading cause of loss of life among patients with *nonsurgical* aneurysms was rupture: 34.6 per cent of the patients died of it; the next most important cause of death was coronary atherosclerosis (17.0%). During the period of observation of the nonsurgical cases, the survival experience was found better and the proportionate incidence of rupture as cause of death lower than previously reported, owing mainly to a change in the type of clinically recognized aneurysms; in recent years aneurysms have been diagnosed earlier in their course. When untreated, small aneurysms (6 cm. or less in diameter) were found to have a longer survival expectancy and a lower overall mortality rate than larger aneurysms (more than 6 cm. in diameter), but they had a rupture rate of over 19 per cent and a survival expectancy that was about half that of treated small aneurysms. In the presence of significant associated (usually cardiovascular) disease and in advanced age, the size of the aneurysm has

an important bearing on decisions of operability.

### Acknowledgment

We wish to express to Dr. Jorge Oglietti our appreciation for his help in the tabulation of clinical data.

### References

1. Cannon, F. A., Van DeWater, J. and Barker, W.: Experience with the Surgical Management of 100 Consecutive Cases of Abdominal Aortic Aneurysm. *Amer. J. Surg.*, **106**: 128, 1963.
2. DeBaKey, M. E., Crawford, E. S., Cooley, D. A., Morris, G. C., Jr., Royster, T. S. and Abbott, W. P.: Aneurysm of Abdominal Aorta: Analysis of Results of Graft Replacement Therapy One to Eleven Years After Operation. *Ann. Surg.*, **160**:622, 1964.
3. Estes, J. E., Jr.: Abdominal Aortic Aneurysm: Study of 102 Cases. *Circulation*, **2**:258, 1950.

4. Gryska, P. F., Wheeler, C. G. and Linton, R. R.: A Review of Seven Years' Experience with Excision and Graft Replacement in 150 Ruptured and Unruptured Aneurysms of the Abdominal Aorta. *New Eng. J. Med.*, **264**: 639, 1961.
5. MacVaugh, H., III and Roberts, B.: Results of Resection of Abdominal Aortic Aneurysm. *Surg. Gynec. Obstet.*, **113**:17, 1961.
6. Schatz, I. J., Fairbanks, J. F., II and Juergens, J. L.: Abdominal Aortic Aneurysms: A Reappraisal. *Circulation*, **26**:200, 1962.
7. Sheranian, L. O., Edwards, J. E. and Kirklin, J. W.: Late Results in 110 Patients with Abdominal Aortic Aneurysm Treated by Resectional Placement of Aortic Homograft. *Surg. Gynec. Obstet.*, **109**:309, 1959.
8. United States Life Tables: 1959-61. U. S. Department of Health, Education and Welfare, Washington, D. C., 1964.
9. Vasko, J. S., Spencer, F. C. and Bahnson, H. T.: Aneurysm of the Aorta Treated by Excision: Review of 237 Cases Followed up to Seven Years. *Amer. J. Surg.*, **105**:793, 1963.
10. Wright, I. S., Urdaneta, E. and Wright, B.: Reopening the Case of the Abdominal Aortic Aneurysm. *Circulation*, **13**:754, 1956.

### DISCUSSION

DR. HARVEY R. BUTCHER, JR. (St. Louis): Dr. Szilagyi is to be congratulated for collecting and comparing a control or untreated group of patients with abdominal aortic aneurysms with the patient he has treated operatively. This is not an easy task. No investigator today would recommend a randomization of all patients with abdominal aneurysms into operative or non-operative therapeutic groups. It is obvious to all that the symptomatic aneurysm should be treated by arterial substitution.

The actuarial method of presenting the mortality statistics used by the authors is the most efficient from the point of view of using all available data toward establishing a true expectancy rate for any condition, the end point of which is death.

Dr. Szilagyi has pointed out to us some of the parameters which are not comparable in his control and treated groups of patients. Correcting for these still has left us with the survival of the operative group better than that of the untreated one. Another cause other than failure to treat operatively for the different positions of the mortality slopes was the inclusion in the non-operative group of some 38 cases of ruptured aneurysm not diagnosed before death. These have resulted in the high mortality rate of the first year of the control group. Operative deaths among patients treated for ruptured aneurysm are not included in the statistics of the treated group.

Beyond the first year the rates of dying of the two groups do not appear to differ significantly. This is not surprising since most of the late deaths are not related to rupture. It would appear that the one question which has needed an unequivocal answer, namely, is the operative mortality less than the likelihood of rupture, has been, at least in part, answered. Late rupture of the aneurysm occurred in some 15% of the control series, the operative mortality, while 13% over-all in the operatively treated group was only 6% in the more recent years.

DR. JERE W. LORD, JR. (New York): Stimulated by Dr. Szilagyi's lucid abstract in the program, I thought it would be worthwhile to look up my own experiences and compare them, between 1949 and 1959, with patients explored for an abdominal aortic aneurysm, and contrast them with the 1952 to 1959 patients who had their aneurysms resected. This in part answers the question that Dr. Butcher raised; namely, that all these were unruptured and were done electively.

There were 23 patients in the nonresected group. Five were before 1953, before we knew how to resect them, and the others were in the next 6 years and were not resected for reasons such as believing that the aneurysm arose above the renal arteries and poor myocardial function on the operating table. Of these 23 patients there were four postoperative deaths. Two were from coronary occlusions, one from a cerebral accident,